FACTS

FOR ENVIRONMENTAL STUDIES

Ontario
Ministry of the Environment

SET 6E

The enclosed materials are designed to be copied. You are invited to do so.

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ACID RAIN

Acid rain is one of the latest environmental problems to rear its ugly head.

It was first brought to public attention in 1971 at the Stockholm Conference on the Environment when it was announced that acid precipitation in Sweden appeared to be affecting reproduction in fish populations. Later studies showed a similar problem in other parts of the world as well as Canada.

While all rainfall is slightly acidic due to carbon dioxide, which occurs naturally in the atmosphere, precipitation in recent years is becoming more acidified due to the presence of sulphur and nitrogen oxides.

The oxides of sulphur are discharged into the atmosphere through the burning of fossil fuels. Factories and power plants are the worst culprits. In the atmosphere the sulphur oxides - in the presence of air moisture - are converted into sulphuric acid. The acid is then carried back to the Earth as rain and snow.

The nitric acid process begins when automobile owners turn the ignition key, for most nitrogen oxides in the atmosphere are produced by the burning of gasoline.

Since the greater part of the world is dependent upon fossil fuel, it's not surprising that acid rain is a world-wide problem.

Effects of Acid Rain

Although acid rain does not directly harm man, it changes the acid-alkali balance in lake and river water and, as a result, threatens fish life.

In the spring, snow which has piled up over the winter melts and flows into lakes and rivers. This run-off occurs at the same time as sensitive life changes are taking place in many fish species and aquatic life. If the snow contained large concentrations of pollutants, fish are exposed to the worst possible water quality conditions at their sensitive stages.

Specific effects includes: failure to reproduce successfully, deformation of adult fish and serious changes in population structures.

In the extreme, fish populations get older with fewer and fewer young fish. Within a few years, if nothing changes, the lake or river is barren of fish life. It is called a dead lake.

Further research also links acid precipitation with reduced growth of forests, poor croplands and the deterioration of many buildings, such as the Taj Mahal.

In Ontario, some lakes in the Sudbury area and in the Muskoka-Haliburtons appear to be affected. This is because the bottoms of these lakes are underlain with bedrock which cannot absorb or neutralize the acid. Lakes which have a limestone bottom tend to fare better.

Unfortunately, it is difficult to pinpoint exactly where the pollution is coming from and how much is produced by a specific factory. Air masses are extremely mobile and unpredictable and they do not know provincial or national boundaries.

To find out what the Ontario Ministry of the Environment is doing about acid precipitation, write:

Information Services Branch,
Ministry of the Environment,
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Experiment: To sample for acid rain.

Materials: short, wide jars with lids
maps of your town or city
test tubes and stoppers
waterproof markers
pH test paper with colour comparison charts

Methods:

1. Mark the locations of factories and power plants on the maps.
2. Choose the locations for the sampling jars, taking into consideration the need for rain to fall directly into the jars, the possibility that the jars will be disturbed, the direction of prevailing winds, etc.
3. It is best to place the jars out just before a rain.
4. Add the rainwater to a test tube containing a piece of pH paper. Shake the tube for about a minute.
5. Compare the colour of the test strip with those on the colour comparison chart.
6. If there are any ponds or lakes nearby, you may try sampling these waters.

NOTE: Normal rainfall, will have a pH of about 5.6 or greater - just slightly on the acidic side of neutral pH 7.

Questions:

1. On which areas of your town or city have higher levels of acid precipitation fallen?

2. Does the existing weather pattern influence the distribution of acid rain?

3. How do the pH values of rain and/or groundwater samples compare to those of familiar substances such as vinegar, soda water, baking soda and household ammonia?

4. Consider the economic reprecussions of acid rain?

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AIR POLLUTION AND PLANTS

Pollutants in the air can damage vegetation, endanger human and animal health, accelerate the deterioration of buildings and clothing, reduce visibility and generally interfere with our enjoyment of the outdoors.

Damage to plant life is an area of particular concern. Air pollutants can cause visible marks on leaves, reduce the growth and yields of plants and even cause death. Such injury to horticultural crops, for example lettuce or tobacco, can result in serious economic problems.

Sources of Air Pollution

In Ontario, air pollutants which cause injury to plants are classed as either local or widespread.

Local pollutants are those that are emitted from a specific stationary source. The vegetation injury occurs in a well defined zone.

Local pollutants are usually 1) sulphur dioxide, 2) fluorides, and 3) particulate matter.

Widespread pollutants are generally referred to as "oxidants". These are produced in the atmosphere during a complex reaction involving nitrogen oxides and reactive hydrocarbons - the main components of automobile exhausts. (As the reaction takes place in the presence of sunlight it is referred to as a photochemical reaction.) The vegetation damage from oxidant buildups in the air can occur over vast areas covering hundreds of miles.

1. Sulphur Dioxide

Major sources of sulphur dioxide are coal-burning operations, especially those providing electric power and space heating. They can also result from the burning of petroleum and the smelting of sulphur-containing ores.

A. Acute injury is caused by the absorption of high concentrations of sulphur dioxide in a short time.

The symptoms appear as lesions (small injuries) which occur between the veins and occasionally along the edges of the leaves. The colour of the affected area can vary from a light tan or near white to an orange-red or brown, depending upon the time of year, the type of plant and weather conditions.

B. Chronic injury is caused by long-term absorption of sulphur dioxide at low concentrations. The symptoms appear as a yellowing of the leaf, and occasionally as a bronzing on the undersurface.

The following plants are considered susceptible to sulphur dioxide: alfalfa, barley, buckwheat, clover, oats, rhubarb, spinach, squash, Swiss chard and tobacco.

2. Fluorides

Fluorides are emitted into the atmosphere from the combustion of coal: the production of brick, tile, enamel frit, ceramics, and glass; the manufacture of aluminum and steel; and the production of hydrofluoric acid, phosphate chemicals and fertilizers.

The damage caused by fluorides appears at the margins or tips of the plants. Little injury appears at the sites of absorption. The injury starts as a gray or light-green water-soaked lesion, which turns tan to reddish brown. With continued exposure the damaged areas increase in size, spreading in or downward.

The following plant species are susceptible to fluoride damages: apricots, prunes, plums, grapes, gladiola, tulips, iris and sweet corn.

3. Particulate Matter

Particulate matter such as cement dust, magnesium-lime dust, and carbon soot, deposited on vegetation, can inhibit the normal respiration and photosynthesis mechanisms within the leaf.

4. Oxidants

Ozone and PAN (peroxyacetyl nitrate) are the main pollutants in smog.

Ozone symptoms usually occur on the upper surface of affected leaves and appear as a flecking, bronzing, or bleaching of the leaf tissues. PAN causes bronzing, silvering, or glazing of lower leaf surfaces.

Ozone sensitive plants include bean, corn, onion, potato, radish, spinach, tobacco and tomato. Plants sensitive to PAN are bean, tomato, lettuce, Swiss chard, and endive.

To find out what the Ontario Ministry of the Environment is doing about air pollution, send for their fact sheet "How Air Pollution Affects Vegetation".

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Experiments:

1. Plant experiments are best done during the spring and summer.
2. Be sure to use plants that are healthy to begin with.
3. You may want to set some potted plants near a power plant, factory, or highway; or you may observe plant life growing near these sources of pollution.
4. Tobacco and spinach plants are especially sensitive to photochemical oxidants.
   If exposed to high concentrations, small dark dots, larger white spots and dead areas may appear on the top of the leaf; the bottom surface will be shiny.
5. Alfalfa, squash and carrot plants as well as the leaves of tomato and lettuce are reliable for monitoring sulphur dioxide in the air, the plants will turn yellow; if exposed to high levels, the leaves will collapse and become water-soaked.

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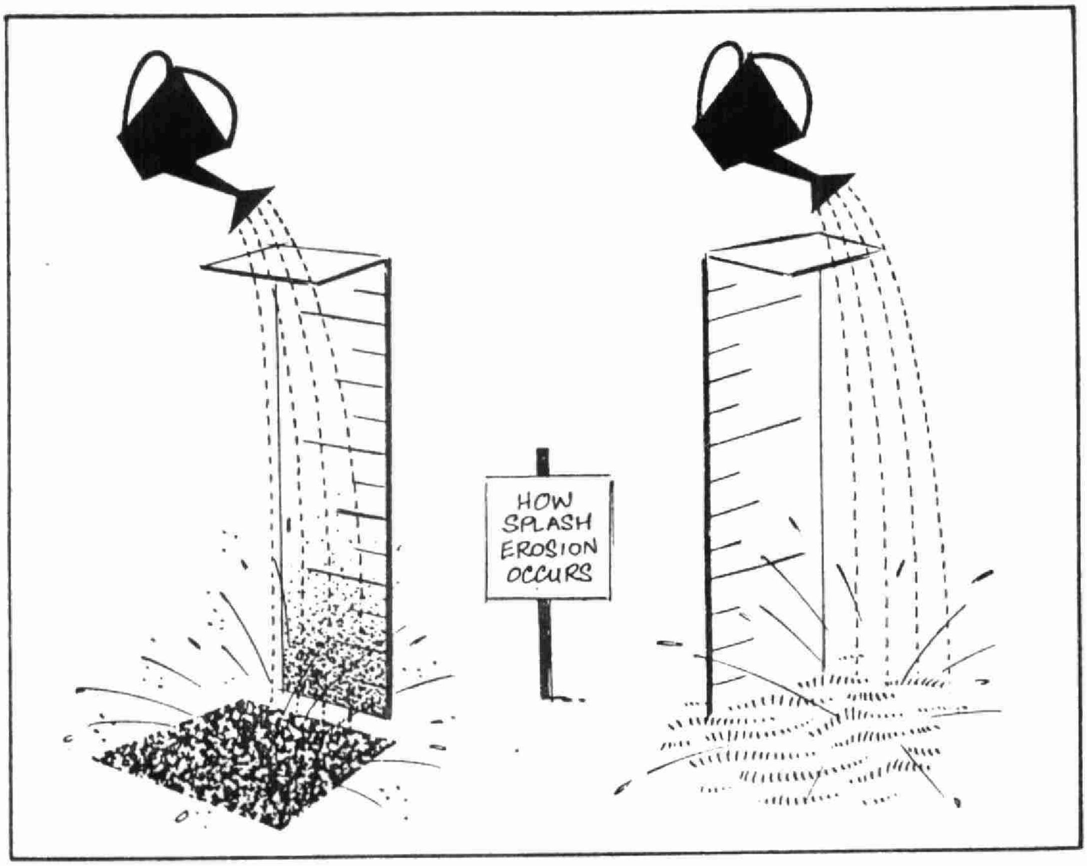
SOIL EROSION

Some facts everyone should know about soil erosion:

1. Soil particles must be dislodged before they can be moved - this is part of the erosion process.
2. When raindrops fall on bare soil a lot of energy is expended. Small clods and granules of soil are broken by the impact of raindrops. Studies made by the Soil Conservation Service, U.S.A., show that from 1 to 1,000 tons of soil per acre may be splashed into the air during one rain.
3. This splashed-up soil consists of single particles that have been dislodged from the mass of soil - and these particles are easily washed away by even slow water movement on the surface. A steep slope is not necessary to move them, but the steeper the slope the greater the soil loss.
4. Fine particles are the most easily moved - leaving heavier particles such as sand and gravel.
5. Splashboards, as sketched here, demonstrate splash erosion. But you can see splashed soil on walls, garden vegetables, and elsewhere after rain.



6. Any kind of soil cover, from grass to crops, cuts down soil movement, as blades and leaves break the impact of falling raindrops.

7. In the home garden, for example, when flower or vegetable plants are small and the soil is exposed, a mulch will prevent splash erosion. When the plants grow bigger, their own leaves lessen splash erosion. (A mulch consists of grass cuttings, etc. spread over the surface of the soil).

A SPLASH EROSION DEMONSTRATION

- Make and set up splashboards as shown in the above diagram. Each board should be about 1 inch 9 (2cm) thick, about 6 inches (15cm) wide; and 3½ft (105cm) long. It should be cut sharp at the bottom end, for driving 6 inches (15cm) into the ground.
- Paint the boards white. Then paint black lines across ± 1 foot intervals; with shorter lines at 3 inch intervals (or metric equivalents) as shown in the sketch. 3 feet (90cm) should be above the ground. Nail a tin shield on top of each board - about 10 inches (25cm) long and the width of the board. The shield helps prevent your demonstration "rain" from washing the soil splashes off the board.
- Drive the two boards into the ground about a yard (a metre) apart. Now, in front of one board, deposit a square yard (square metre) of soil, about 2 inches (5cm) deep. The other board should be on lawn grass.
- Your other equipment consists of a stepladder and a watering can.

<u>To demonstrate splash erosion in public</u>:

- From a height of about 5 feet, rain down water from the watering can on the grass in front of one board. Then rain down another can of water from above the other board, onto

the loose soil. Spectators will be able to observe the amount of soil splashed, while the demonstrator explains facts about splash erosion as set out above.

- Four display cards, nailed to sticks driven into the ground, could feature the following messages:

HOW SPLASH EROSION OCCURS

THE EXPLOSIVE ACTION OF ONE RAINDROP CAN HURL A SOIL PARTICLE 1 YARD HIGH, AND MORE THAN A YARD AWAY.

A RAINDROP FALLS AT A SPEED OF 24 TO 30 FEET A SECOND, IN STILL AIR.

ONE HEAVY RAIN CAN LOOSEN AND CARRY AWAY AS MUCH AS 338,000 POUNDS OF SOIL FROM A SINGLE ACRE OF POORLY PROTECTED SOIL.

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THE WONDERS OF ICE

Ice is a familiar substance to Canadians in the winter. We watch for it on roads, scrape it off the windshield of our cars, play on it and we have even built a national sport - hockey - around it. Yet few of us have ever done more than take it for granted. Ice, however, can be a fascinating field of study.

FORMATION OF ICE

Most of us are used to waking up one winter morning and finding the nearby lakes, rivers or ponds frozen over. But ice rarely forms suddenly on a lake.

On cold, clear winter nights, surface heat from the lake escapes into the atmosphere due to the absence of insulating cloud cover. This causes the surface temperature to drop quickly. If the air is dead calm, then a very thin (one-tenth of an inch) layer of surface water may cool a fraction of a degree below the freezing point. (Any wind will immediately mix the water and destroy the layer.) This state of supercooling occurs just prior to freezing.

In most cases, ice usually begins with water freezing to a rock touching the surface of the water, or by snowflakes drifting onto the water from the shore. This gives the ice a starting place from which to grow. The initial ice crystal as it grows frequently adopts the shape of a blade that may shoot across the water with a hissing sound. These blades radiate at various points on the water's surface and intersect in a gridlike, trellis pattern. This pattern can sometimes be seen in early morning before the sun has had a chance to melt the ice.

If the cold lasts for several days then this first cover may remain all season. Usually, though, the morning sunlight and the warmer temperatures of the day melt the initial ice skim and the process may be repeated several times until the permanent layer is finally established.

If the ice forms under the above conditions, the result will be the familiar black ice. (The ice is not really black but appears so because of the light absorbing waters below it.)

Ice may also form during the day when snow is falling. The snow not only adds ice to the water but the crystal acts as a focal point for the additional growth of the ice. The accumulation of snow on the water causes it to collect together and soon the whole mass freezes by the infiltration of water from below. This type of ice is called white ice because of the entrapment of air in

the snow during freezing.

Activity 1

To show how ice begins to form.

Fill a styrofoam cup with cracked ice or crushed ice cubes. Add salt one teaspoon at a time and stir. Check the temperature. Continue to add salt until the temperature will not go any lower. Place a pill bottle filled with cold tap water in the middle of the ice mixture. Use a clean thermometer to stir the water in the bottle until the temperature drops to three degrees above freezing. Leave the thermometer in the bottle and do not jar, or disturb the water. Observe the temperature on the thermometer until it reaches several degrees below freezing and then tap the container gently. Observe the temperature and the contents of the bottle.

Teacher Background:

Water does not always freeze when the temperature drops below 0 C. When this occurs the water is called super-cooled. Super-cooled water is unstable. Any slight disturbance, even by a speck of dust falling on it, will cause ice crystals to form. The molecules become less active when the water freezes and give off their change in energy of motion in the form of heat. The temperature rises momentarily until the heat is absorbed by the ice and salt mixture outside. Moisture, suspended in the atmosphere, often freezes instantly when it strikes the ground or

other objects. When this occurs a layer of ice or glaze forms.

Activity II

To make ice crystals.

Pour trickles of hot water onto a piece of glass which has been left outside for several hours on a cold day. Examine the crystals which form with a hand lens as the water freezes. Put water in an aluminum pie plate and place it outside to see the formation of larger needle-like crystals. (The formation may take a little time.)

Activity III

To show the colours of ice.

Place the same volume of water but at different temperatures in tin cans of equal size. Place these out of doors on a cold day.

Obtain paint colour charts in a range of greens, whites and greys. When ice forms in the cans, compare the colours to the charts. Allow the cans to stand outside for as many days as possible, comparing the colours daily.

Repeat the activity using water at the same temperature and cans of equal size but different amounts of water.

EXPANSION OF ICE

People, who have boathouses, docks or retaining walls around their cottage property are often concerned about the effects of ice on their buildings. For the pressure caused by expanding ice can destroy permanent structures.

Soon after an ice sheet is formed, and before the next heavy fall of snow, it both thickens and grows sideways. This sideways growth toward the shore begins with the cooling of the ice cover during the night.

The drop in temperature causes the ice to contract and the decrease in size puts stress on the ice cover so that cracks develop. Water seeps into the cracks and freezes.

When the sun comes up, the ice slowly expands with the rising temperature. The ice sheet is now larger than its original size because of the new ice formed during the night. During the day, the ice will again crack due to the pressures of expansion and water will again freeze in the fissures. Thus the cover will increase its size and pressure against the shore.

Another way that ice may thicken is through the infiltration of water, from cracks in the ice, into the overlying snow cover. The water then freezes the snow grains together into an ice

mass that becomes part of the underlying lake ice. In addition to the seepage of water from cracks, water may also be added to the snow by the melting snow itself and, of course, by an unseasonable rain.

Activity IV

To show how ice expands.

Fill a bottle with water, lightly cap it and place it outside on a cold winter day or in a freezer. (The bottle could be placed inside a plastic bag to reduce the danger of cuts from broken glass.) Observe how the bottle breaks - does it shatter or just crack along certain lines? Repeat the activity using identical bottles with different levels of water and, in some cases, leave the caps off.

ICE RIDGES

An ice ridge (or more technically, a raft) in the middle of a lake is initially a crack in the ice cover caused by opposing pressures. As the pressures increase, the ice becomes pinched up and forms an ice barrier. If the ice cover on the two sides of the crack is approximately equal in area, the ice will be equally shoved up. However, if one side is much greater than the other, the larger side will dominate the rafting and push over the smaller side.

The weight of the ice ridge itself causes the ice surrounding it to crack and sink below its normal level, allowing water to seep onto its surface. These ridges may form over several days or grow suddenly during the rapid warming temperatures of a single day.

On a very large lake, such as Erie or Ontario, ridge growth could be due to wind stresses on the large expanse of ice cover. Lake depth and shoreline geography can also be factors.

Ridges continue to grow and the ice continues to expand as long as they are free from snow. All activity stops once the snow cover is more than a couple of inches deep.

All ridges should be approached with caution. Snowmobiles could easily catch a runner and the weakened condition of the ice may break under the weight of the machine. If crossing a ridge on foot, avoid wet spots and areas of intensely cracked ice.

SPRING BREAK-UP

As the warming temperatures of spring approach, the snow layers on the ice begin to melt. Then, gradually, the sun's rays cause a process of internal melting within the ice along the crystal boundaries. When the melting separates the crystals, they resemble long candles.

Activity V

To observe the "candling" of ice.

On a bright, sunny winter day, take a piece of lake ice out of the sheet and expose it to sunlight. After a short time, break the ice with your hands. The resulting pieces are "candles" of melted ice, which are really the long crystals that make up the ice sheet.

As warm weather continues, the melting ice will usually break up into candles floating on the surface, (ice never sinks since it is less dense than water.) The wind will eventually push the small pieces to the shore where they dissolve.

WORDS OF WARNING

1. A four-inch thickness of ice is sufficient to hold a man's weight if the weather is cold.
2. The warmer the ice, the weaker it is.
3. Be wary of strong currents and avoid all areas where streams enter lakes as they are notorious for thin ice.
4. Approach ice ridges with caution.
5. When testing ice always stay near the shore and never go out without a partner.